Accepted Manuscript

An innovative large scale integration of silicon nanowire-based field effect transistors

M. Legallais, T.T.T. Nguyen, M. Mouis, B. Salem, E. Robin, P. Chenevier, C. Ternon

PII: S0038-1101(17)30637-8
DOI: https://doi.org/10.1016/j.sse.2017.11.008
Reference: SSE 7363

To appear in: *Solid-State Electronics*

Please cite this article as: Legallais, M., Nguyen, T.T.T., Mouis, M., Salem, B., Robin, E., Chenevier, P., Ternon, C., An innovative large scale integration of silicon nanowire-based field effect transistors, *Solid-State Electronics* (2017), doi: https://doi.org/10.1016/j.sse.2017.11.008

An innovative large scale integration of silicon nanowire-based field effect transistors

M. Legallais[1,2], T. T. T. Nguyen[1], M. Mouis[2], B. Salem[3], E. Robin[4], P. Chenevier[5], C. Ternon[1,3]
[1]Univ. Grenoble Alpes, CNRS, Grenoble INP*, LMGP, F-38000 Grenoble, France
[2]Univ. Grenoble Alpes, CNRS, Grenoble INP*, IMEP-LaHC, F-38000 Grenoble, France
[3]Univ. Grenoble Alpes, CNRS, LTM, F-38000 Grenoble, France
[4]Univ. Grenoble Alpes, CEA, INAC, MEM, F-38000 Grenoble, France
[5]Univ. Grenoble Alpes, CEA, CNRS, SYMMES, F-38000 Grenoble, France
*Institute of Engineering Univ. Grenoble Alpes
Email: celine.ternon@grenoble-inp.fr
maxime.legallais@grenoble-inp.fr

***Abstract*— Since the early 2000s, silicon nanowire field effect transistors are emerging as ultrasensitive biosensors while offering label-free, portable and rapid detection. Nevertheless, their large scale production remains an ongoing challenge due to time consuming, complex and costly technology. In order to bypass these issues, we report here on the first integration of silicon nanowire networks, called nanonet, into long channel field effect transistors using standard microelectronic process. A special attention is paid to the silicidation of the contacts which involved a large number of SiNWs. The electrical characteristics of these FETs constituted by randomly oriented silicon nanowires are also studied. Compatible integration on the back-end of CMOS readout and promising electrical performances open new opportunities for sensing applications.**

Silicon Nanowire; Nanonet; Integration; Field Effect Transistor; silicidation; Morphological and electrical characterizations

1. Introduction

Silicon nanowire (SiNW) field effect transistors (FET) are potential candidates for biosensing applications [1]. Although their fabrication has been attracted intense research effort for the past two decades, their large scale integration remains an ongoing challenge [1]. On the one hand, taking advantage to the current and well-controlled Complementary Metal-Semiconductor (CMOS) process, the top-down method is up-scalable but requires many successive steps which involves costly facilities. On the other hand, despite the flexibility of SiNW growth, time consuming technology and complex equipment still impede the industrial-scale production of FETs using bottom-up method.

To overcome these issues, an assembly of randomly oriented nanowires called nanonets [2] can be considered with the aim of facilitating their handling and integration while benefiting from the potential of intrinsic nanowire properties [3]. In such homogenous and random networks, the electrical properties are governed by the percolation theory [4] in which current flows via conducting paths involving SiNWs and NW/NW junctions. Despite SiNW oxidation in air, we recently stabilized electrically long-channel Si nanonet resistors using low thermal annealing (≤400°C) treatment [5], offering a broad range of applications. Thanks to this major technological breakthrough, Si nanonet-based field effect transistor may be envisioned but it requires an excellent control of the integration and the silicidation process in order to produce reliable devices.

Here, we first demonstrate the fabrication of Si nanonet field effect transistors using standard microelectronic process. We show that silicidation process can be controlled via chemical and electrical characterizations even though a large number of SiNWs are involved in the conduction. Then, the output and transfer characteristics of these devices are studied as a function of the SiNW density in the network.